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LETTER

Exploring pangolin rehabilitation practices and challenges in Africa and Asia

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Abstract

Wildlife rehabilitation is often overlooked in conservation. Pangolins rescued from wildlife trade, vehicle collisions, habitat destruction, and other human-induced threats are sent to rehabilitation centers for recovery and release. This study provides preliminary information from a practitioner-based assessment of pangolin rehabilitation practices across Africa and Asia, exploring reported similarities and differences in rehabilitation between regions. We administered a questionnaire that was completed by 28 individuals and conducted 14 semi-structured interviews with individuals experienced in pangolin rehabilitation. Results highlight both similarities and differences in rehabilitation practices across regions based on practitioner experiences. Rehabilitators of Africa more frequently emphasized limited funding and resources as key challenges, while the rehabilitators of Asia more often cited unsuitable release habitats and low public awareness. Participants from Africa emphasized their involvement in post-release monitoring, while participants from Asia emphasized government involvement in their rescues and releases. Stress and welfare concerns remained relatively the same, but differences were reported in the most commonly observed complications. Further research is needed to examine rehabilitation processes, mortality rates, post-release support, and stress indicators among pangolin species. Wildlife rehabilitation represents a potentially important aspect of conservation strategy, particularly for pangolins and other species susceptible to extinction.

KEYWORDS

animal welfare, human dimensions, mixed-methods research, social science, stress, wildlife rehabilitation

1 | INTRODUCTION

As one of the most threatened species groups globally, pangolins have been the focus of significant research and conservation efforts at an international and national level (Heighton & Gaubert, 2021). The eight extant pangolin species are distributed across Africa and Asia, with four species occurring on each continent (Gaudin et al., 2009), and are threatened by overexploitation (Heinrich et al., 2017; Ingram et al., 2018; Newton et al., 2008),

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habitat loss (Nursamsi et al., 2023), climate change (Gao et al., 2022; Qasim et al., 2024), and human-related threats such as vehicle collisions and electric fences (Pietersen et al., 2014; Suwal et al., 2023). Confiscation and rescues of pangolins have increased over the past 15 years, likely reflecting increased enforcement and awareness of illegal wildlife trade, along with human-induced threats such as accidental injuries and human wildlife conflict (Heinrich et al., 2017; Omifolaji et al., 2022; Zhang et al., 2022; Zhang, Chen, et al., 2024; Zhang, Hong, et al., 2024). Rescued and confiscated pangolins are sent to rehabilitation centers to be evaluated and treated for their injuries, with plans to release them back into the wild once they have fully recovered (Wright & Jimerson, 2020). While research and conservation efforts have focused on populations, habitats, and ecosystems, it is important to consider the rehabilitation of individual animals as a potentially important component of conservation strategy (Guy et al., 2013; Saran et al., 2011). Utilizing the perspective of practitioners directly involved in wildlife rehabilitation remains largely underexplored in an empirical format.

Wildlife rehabilitation is the "treatment and temporary care of injured, diseased, and displaced indigenous animals, and the subsequent release of healthy animals to appropriate habitats in the wild" (Miller et al., 2012, p. ix). Release protocols in wildlife rehabilitation typically follow either a soft release, where animals are gradually acclimated to a new environment with external support (Mitchell et al., 2011), or a hard release, where they are released directly into the wild without further support (Hardman & Moro, 2005).

The rescue, rehabilitation, and release of pangolins remain largely unexplored as a sector of conservation (Wright & Jimerson, 2020), although there has been extensive research on the management and captive breeding of pangolin species across Asia (Hua et al., 2015; Liu et al., 2021; Yan et al., 2021; Zhang et al., 2017). These studies have advanced pangolin conservation by providing information on housing, transport, artificial diets, husbandry, and breeding challenges. Such studies have identified stress as an area of concern for pangolins in captivity (Challender et al., 2011; Hua et al., 2015; Zhang et al., 2017), warranting a further evaluation of possible welfare and stress implications in rehabilitation. Despite some similarities, the distinction between captive breeding and rehabilitation programs lies in their main objective. Captive breeding programs are designed with the intention of increasing the population through an artificial environment and may see the release of some individuals (Snyder et al., 1996), while rehabilitation programs focus on treating and preparing all individuals—with exceptions—for release back into the wild (Saran et al., 2011).

Conservationists have sometimes questioned the impact and contribution of wildlife rehabilitation to broader conservation efforts as rehabilitation is often centered at the individual level, rather than populations or ecosystems (Aitken, 2017; Paterson et al., 2021). Nevertheless, wildlife rehabilitation may represent a useful conservation tool (Guy et al., 2013), particularly for endangered or K-selected species where the survival of individual animals can have relevance for the genetic diversity of a population (Paterson et al., 2021). Yet, the effectiveness of wildlife rehabilitation depends on factors such as treatment, resources, post-release survival and monitoring, and threats in the wild. The effectiveness of rehabilitation is also based on the people that practice this field. Wildlife rehabilitators can contribute to the development of species-specific expertise, particularly through the accumulation of practical knowledge on handling, treatment, and study of rare species (Tribe & Brown, 2000).

Here, our study aims to: (1) provide preliminary comparative information on pangolin rehabilitation across Africa and Asia; (2) explore how these practices differ regionally or among species; and (3) examine the stress and welfare implications of pangolins during rehabilitation. We hypothesize that rehabilitation strategies differ between Africa and Asia, particularly due to resource availability, institutional and government support, and post-release management. By exploring practitioner experiences across pangolin range states and identifying possible complications in welfare, we aim to provide descriptive information on the current practice of pangolin rehabilitation and highlight areas where further research is needed to support evidence-based improvements.

2 | METHODS

We used a mixed-methods approach (Newing, 2010) to provide a deeper understanding of pangolin rehabilitation by combining a quantitative questionnaire with qualitative semi-structured interviews. Participants were recruited via purposive sampling (Patton, 2002) through the International Union for Conservation of Nature (IUCN) Species Survival Commission Pangolin Specialist Group (PSG), and snowball sampling (Naderifar et al., 2017) as PSG members referred rehabilitators outside the PSG.

This study was approved by the University of Kent Ethics Committee #20241712057577661. Informed consent was obtained from all participants to ensure ethical compliance and voluntary participation in the study. Throughout the study, we do not mention or comment on the rehabilitation practices of individual organizations.

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2.1 | Data collection

2.1.1 | Questionnaire survey

Our questionnaire was developed on Microsoft Forms and distributed to the PSG email list with a request to be completed only if the individual had experience with pangolin rehabilitation along with snowball sampling to allow referrals. Referred individuals were contacted via email, briefed on the purpose of the study, and provided a hyperlink to the survey. The questionnaire contained 36 questions (Data S1, Supporting Information) structured into four sections: demographic information (7 questions), pangolin rehabilitation (18 questions), welfare and stress (7 questions), and 4 supplementary questions. Participants ($n = 28$) were asked to provide responses for their primary country of work and focal pangolin species, with the option to answer the welfare questions for a second species. We allowed multiple responses for most of the questions and had an "Other" option in case the participant wanted to expand on their responses or provide a different answer; however, "Other" responses are not presented in this study as they were too diverse to draw reliable broad conclusions.

2.1.2 | Semi-structured interviews

We began by inviting PSG members via email to partake in our study, targeting individuals with experience in pangolin rehabilitation. Hence our message was only relevant to a subset of people. We recruited seven participants this way, and seven participants through snowball sampling for a total of 14 participants. Seven other individuals were invited to participate through snowball sampling but were unavailable during our data collection period. Interviewees included rehabilitators, veterinarians, and academics with experience in pangolin rehabilitation. Interviews were conducted in May and June 2024 via internet video call (on Microsoft Teams; six participants), mobile telephone call (seven participants), and an in-person meeting (one participant). Discussions covered the rehabilitation of pangolins in the participant's country of work, welfare and stress complications in pangolins, the relationship between pangolin and rehabilitator, and pangolin conservation (Table 1) through an interview guide (Young et al., 2018). Interviews lasted between 33 and 113 min ($m = 64$ mins) and were recorded based on the approval of the participants. All interviews were performed by the first author.

TABLE 1 Guide for semi-structured interviews.

Topic	Questions
Pangolin rehabilitation	1. How do you define success in pangolin rehabilitation? 2. What constitutes a rehabilitated pangolin? 3. What does a typical success story look like?
Rehabilitation techniques	4. What techniques have you developed particularly for pangolin species?
Animal welfare	5. What welfare and stress complications have you seen present in pangolins? 6. How is animal welfare prioritized in rehabilitation centers?
Resilience	7. What have you learned about the resilience of pangolins in a rehabilitation setting?
Future of pangolin conservation	8. 20–30 years from now, what do you see pangolin conservation being? 9. Where should current efforts be directed?
Nature and people	10. Can you describe the most typical relationship between pangolin and rehabilitator?

2.2 | Data analysis

2.2.1 | Questionnaire survey

Descriptive statistics were used to demonstrate response differences between participants from Africa and Asia. Data was analyzed using R version 4.4.1. (R Core Team, 2024). Participants ($n = 28$) were allocated into two groups: Africa ($n = 17$) and Asia ($n = 11$). To account for the differences between sample sizes, response frequencies were presented as percentages based on the total number of participants within each continent.

2.2.2 | Semi-structured interviews

We performed a thematic analysis on the interview transcripts (Braun & Clarke, 2006) using NVivo 14 (Lumivero, 2023). A deductive coding approach was used due to previous literature concerning the rehabilitation and captivity of pangolins, and interest in specific topics such as motivations, challenges, and stress. However, new codes were also explored as identified through inductive coding. Phase 1 involved transcribing, annotating, and reading the interviews for initial observation. Once familiarization with the data seemed appropriate,

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phase 2 began with coding across the entire data set with the deductive codes. Phase 3 focused on exploring potential themes as all the codes were combined or redefined. Themes were reviewed in relation to the coded extracts to ensure enough support from the data in phase 4, while phase 5 was the final refinement of themes. The final phase, phase 6, concluded with the write-up and selection of coded extracts for publication. To maintain confidentiality, extracts were only credited to a participant's continent or pangolin species.

3 | RESULTS

3.1 | Questionnaire survey

Participants who completed the questionnaire ($n = 28$) represented 24 countries: 16 from Africa and 8 from Asia (Figure 1). Experience ranged from 3 to 25 years ($m = 9.18$, SD = 6.50). Among the 28 participants, 21 (75%) indicated having previous experience with wildlife rehabilitation outside of their work with pangolins, comprising 14 of 17 participants from Africa and 7 of 11 from Asia. Out of the 28 participants, 50% expressed having received training specific to pangolin rehabilitation: 7 of 17 participants from Africa and 7 of 11 from Asia. The primary barrier to pangolin rehabilitation in Africa was funding and resources, as selected by seven participants from Africa ($n = 17$), while six participants from Asia ($n = 11$) selected unsuitable habitat for release and lack of awareness (participants did not further specify their target audience when referring to lack of awareness based on the questionnaire design). The barriers to wildlife rehabilitation were similar across Africa and Asia (Data S2), although a higher proportion of participants from Africa identified legislation and regulations as a challenge compared to those from Asia, without further specifying the nature of these constraints. The reasons for admittance of pangolins into rehabilitation centers (Appendix S3) were consistent across continents, except for human–wildlife interactions, as a higher proportion of participants from Asia indicated this reason.

Further differences between continents were observed in organizational practices, such as participation in post-release monitoring, as 76% of participants from Africa acknowledged their organization plays a role in post-

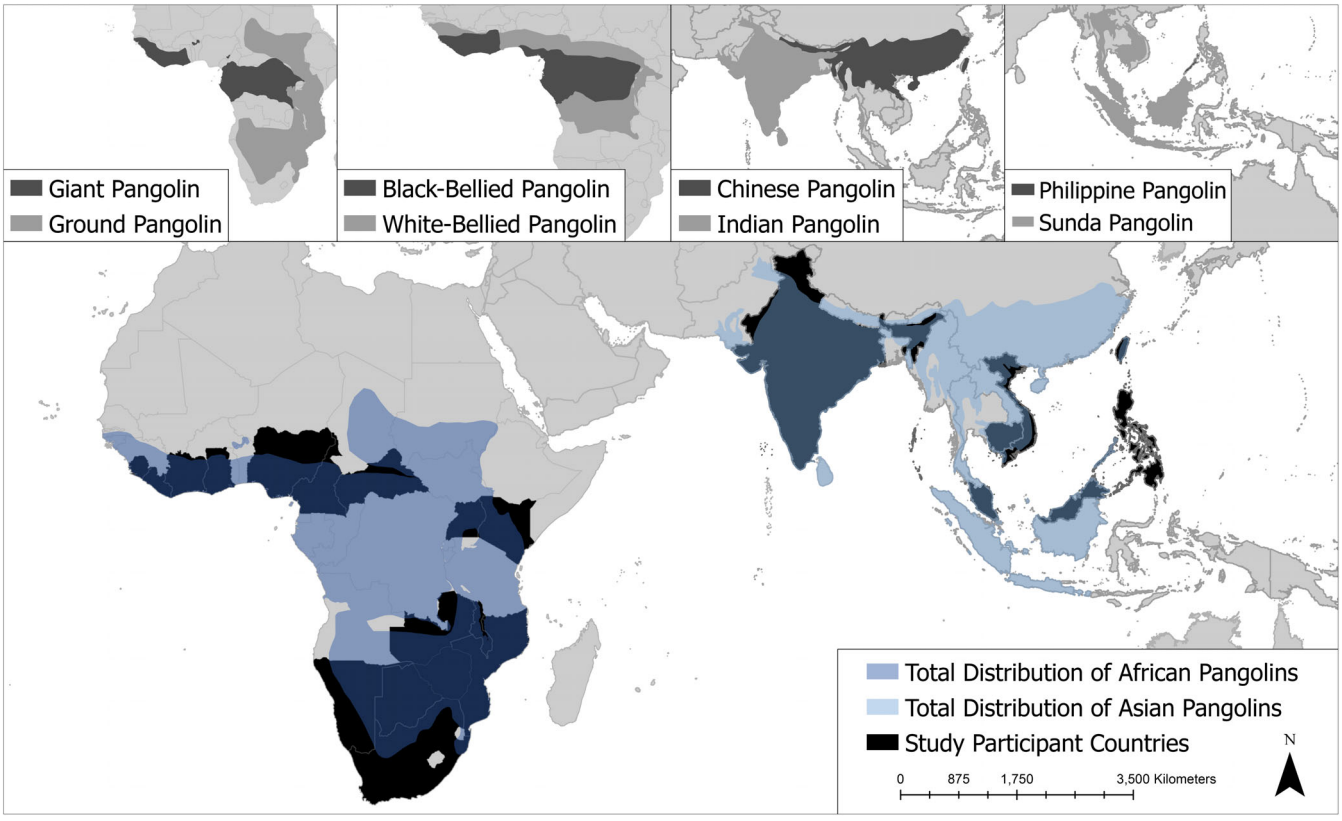


FIGURE 1 Countries across Africa and Asia represented in our study (black) and the distribution of the four African pangolin species and the four Asian pangolin species. Data sources for distribution maps: Challender, Willcox, et al. (2019); Challender, Wu, et al. (2019); Ingram et al. (2019); Mahmood et al. (2019); Nixon et al. (2019); Pietersen, Jansen, and Connelly (2019); Pietersen, Moumbolou, et al. (2019); Schoppe et al. (2019).

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release support, compared to 45% of participants from Asia. In the same manner, 76% of participants from Africa acknowledged the existence of established protocols regarding the release of pangolins, compared to 55% of participants from Asia. Notably, all participants from Asia ($n = 11$) indicated they receive support from the government in the rescue and release of pangolins, compared to 12 of 17 participants from Africa. All participants (100%) reported releasing all rehabilitated pangolins as the primary outcome, selecting suitable habitat and proximity to humans as the key release factors (Appendix S4). Accordingly, protected areas were selected as the typical release site by participants from Asia (91%; 10/11) and Africa (88%; 15/17). However, if pangolins were not to be released back into the wild, physical injuries were the most prevalent cause, according to 73% of participants from Asia and 88% of participants from Africa. Despite some pangolins being non-releasable due to injuries, only 53% of participants mentioned euthanasia: 11 of 17 participants in Africa and 5 of 11 participants in Asia.

The welfare component had a total of 32 responses, as four participants completed this section for a second species. Seven pangolin species were covered in the responses of the survey: Ground pangolins (*Smutsia temminckii*) being the most common with 13 responses, followed by Sunda pangolins (*Manis javanica*) with 8, white-bellied pangolins (*Phataginus tricuspis*) with 6, and black-bellied pangolins (*Phataginus tetradactyla*) with 2. Philippine (*Manis culionensis*), Indian (*Manis crassicaudata*), and Chinese pangolins (*Manis pentadactyla*) each received 1 response. The stress and welfare complications in pangolins were consistent across Africa and Asia (Figure 2), except for weight loss and increase in infectious diseases, as a higher proportion of participants from Africa selected these issues. Additionally, 90% (19/21) of the participants in Africa selected weight loss as the most alarming concern, while 73% (8/11) of participants in Asia selected loss of appetite. The most common injury in pangolins (Appendix S5) observed by participants from Africa was dehydration, while participants from Asia equally reported puncture wounds and dehydration. Foraging was the most selected positive welfare indicator in both continents (Figure 3), followed by increase in appetite in Africa and climbing in Asia. When asked to choose a single indicator of positive welfare, 53% (17/32) of participants selected interacting with enrichment items.

3.2 | Semi-structured interviews

Participants represented 12 countries: 7 in Africa and 5 in Asia (Figure 1). Three major themes were identified by the thematic analysis with 10 sub-themes. The three themes are: (1) challenges of rehabilitation, (2) strategies of rehabilitation, and (3) pangolin well-being (Figure 4). Seven of the eight known pangolin species were covered in the interviews; giant pangolins were the exception.

3.3 | Theme 1—Challenges of rehabilitation

3.3.1 | Captivity

Nearly every interview emphasized challenges in keeping pangolins in captivity. Participants from both continents described pangolins as difficult to manage in captivity, particularly because of issues related to feeding and their initial

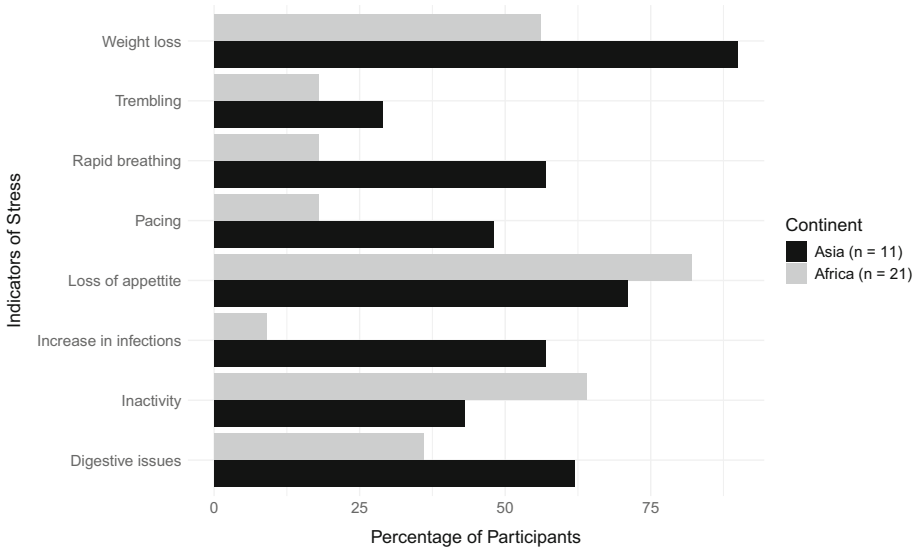


FIGURE 2 Comparison of welfare and stress indicators in pangolins observed during rehabilitation based on participant responses from Africa ($n = 21$) and Asia ($n = 11$; percentages calculated based on the total number of participants per continent). Participants in this study varied from wildlife rehabilitators, veterinarians, and other professionals with prior experience in the rehabilitation process of pangolins.

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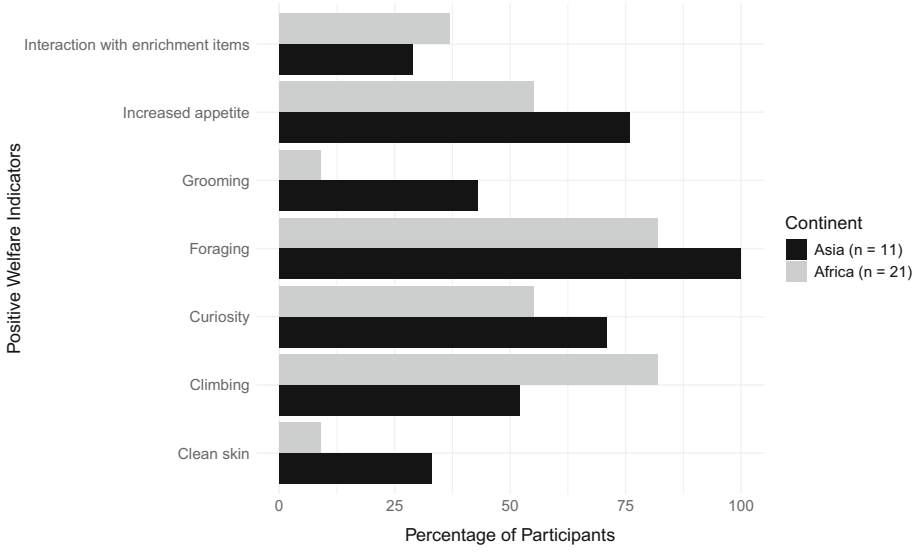


FIGURE 3 Comparison of positive welfare indicators observed in pangolins during rehabilitation based on participant responses from Africa ($n = 21$) and Asia ($n = 11$; percentages calculated based on the total number of participants per continent). Participants in this study varied from wildlife rehabilitators, veterinarians, and other professionals with prior experience in the rehabilitation process of pangolins.

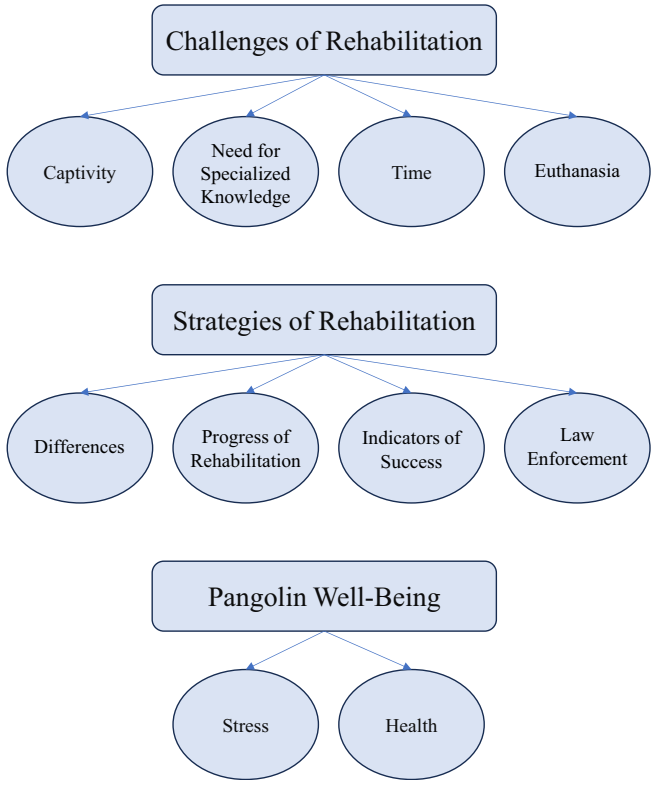


FIGURE 4 Concept map of the themes and sub-themes of this study related to the rehabilitation of pangolins in Africa and Asia according to the responses of the participants in the study.

adaptation to a captive environment. Feeding in captivity was discussed several times due to lack of near foraging habitat, resources, or refusal from the individual:

> We had limited foraging sites when we took [ground pangolins] out... Our foraging sites have been used at least five years before I arrived and they are just obliterated. [Participant from Africa]

> [Indian pangolins] won't feed on the artificial diet which you give to them. [Participant from Asia]

> [Ground pangolins] don't eat in captivity, so we have to let them forage for themselves. [Participant from Africa]

Another challenge associated with captivity was the reported difficulty of pangolins in adapting to human-made surroundings, which may lead to periods of inactivity, as observed in white-bellied, black-bellied, Sunda, and Chinese pangolins. Several participants shared that new environments pose a challenge, particularly due to unfamiliar smells and noises, despite the environment being "controlled" and pangolins accommodated with all the resources necessary. Accordingly, a few participants described how they had to rearrange their enclosures to better match natural conditions, such by increasing the space of the enclosure, adding dirt pits, branches, and other natural forage, enrichment items to foster natural behaviors, and limit their contact with people to follow the circadian rhythm of the species.

3.3.2 | Need for specialized knowledge

All participants emphasized that pangolin rehabilitation requires species-specific knowledge that is not always transferable from other wildlife rehabilitation or veterinary experience. Participants described that their initial encounter showed them how many specifics they had to

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learn about pangolins, particularly in handling, assessing their conditions, and treatment decision-making:

> There are some basic principles that you think apply [but] they actually don't... Everything that you would typically expect a mammal to do is not something that you can apply to a pangolin. [Participant from Africa]

> You have to be very critical in treating, diagnosing, and using preventive medicines. When you actually bring your experience to large animal or wildlife [rehabilitation] where you may have limited resources or limited experience, this is where that experience comes in place. [Participant from Asia]

Participants from both continents described being uncertain trying new rehabilitation techniques, procedures, or medicines, especially when resources are limited or individuals are in critical conditions that require immediate action. These responses suggest that access to species-specific rehabilitation guidance remains an important gap.

> ...pangolin is one of the hardest animal to be kept in captivity and to treat... With all the limited resources you have, that is one big headache, you know? [Participant from Asia]

3.3.3 | Time

Time was stated as a challenge due to the complexities and daily requirements of pangolins. Participants who worked with ground pangolins emphasized the importance of going on foraging walks with individuals in captivity, noting that the frequency and duration of such walks make them time-consuming. Foraging walks depend entirely on the pangolin:

> You've been walking for seven hours in circles and the pangolin hasn't eaten. [Participant from Africa]

Participants who worked with white-bellied pangolins described how being placed on pangolin duty means your entire workload for that day will be that individual pangolin:

> If [the organization] put you on pangolin, you are going to do only pangolin for the day... Morning to evening and night, you are only there to focus on the pangolin and you are not going to do any other work... You have to walk the pangolin, you have to feed the pangolin and know that the pangolin is going to be okay for that day. [Participant from Africa]

Time was only mentioned as a challenge for ground and white-bellied pangolins due to their specific foraging behaviors.

3.3.4 | Euthanasia

Several participants mentioned the use of euthanasia as a last resort for pangolins who are brought with conditions or injuries from which they will not recover. Participants explained how sometimes it is best to euthanize pangolins as a way to end suffering if they do not see the individual thriving or adjusting to the temporary conditions of rehabilitation:

> Sometimes immune systems are just too compromised that not even medication or antibiotics can help them, so then you have to make the humane decision to euthanize... put them out of their suffering. [Participant from Africa]

One participant from Africa working with white-bellied and black-bellied pangolins described how those who arrive with large wounds on their tails will be euthanized due to reliance on their tails. A participant from Asia described how euthanasia was frowned upon by the government due to ethical and cultural dilemmas.

3.4 | Theme 2—Strategies of rehabilitation

3.4.1 | Differences between the rehabilitation processes of different institutions

Participants provided detailed explanations regarding some of the rehabilitation processes for pangolins within their institutions (Table 2).

Post-release support was mentioned predominantly by participants from Africa as they managed post-release themselves or collaborated with other organizations. Participants from Asia emphasized the lack of resources and funding as a limiting factor in pangolin rehabilitation more frequently than those from Africa. While both continents described having infectious disease screenings for rescued pangolins, only participants from Asia reported having a quarantine period in different enclosures.

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TABLE 2 Descriptions of example pangolin rehabilitation scenarios by different institutions in Asia and Africa.

Continent (pangolin species)	Quote	Key points
Asia (Sunda)	"Generally, we rescue them on site, we do infield stabilization and first aid. Vet always goes to a rescue and deals with what needs to be dealt with immediately. Then, [pangolin] arrive at the center and they're put immediately into quarantine. Within the first three days of quarantine, we will do a full health check, anesthetized health check, full blood work, urinalysis, ultrasound, and general physical exam. We'll do various treatments depending on what we find. They'll stay 30 days in quarantine where we'll monitor appetite, feces, treatments, and any surgical procedures. Generally from there we have a pretty good timeline and we try to release them quite soon after." "Pangolins is just like our part time jobs. All we do is rescue, monitor them, do a health check, and immediately release them."	• On-site rescues • Quarantine for 30 days with health monitoring and appropriate treatments • Full health check • Release depends on recovery progress • Artificial diets
Asia (Indian)	"If the species is captured from the wild and if it is possible to release them, the animal is [to be] released back into the wild. Depending on the situation of the animal, if it is not wounded or highly tired or stressed, you can easily release them into the wild."	• Immediate release based on three criteria: minimal stress, no significant injuries, or exhaustion
Asia (Philippine)	"We just keep them for one, two, three days, hydrate, recheck, then we release them back to where they came from."	• Brief rehabilitation process through hydration and health checks • Release back to original location
Asia (Chinese)	"We feed them ant nests for the first week. We will find and provide for the pangolins, we don't have termites but we have ants, but we are not always [able] to provide them the ants because ants are very difficult to collect. So we also provide them artificial diet when they start [inaudible], we will update the artificial diet and increase day by day for the [injured] pangolins that have to stay longer... When they are ready to be released, we add more ants to their diet."	• Gradual increase in diet according to recovery • Increase in diet before release • Artificial diets • Similar process to Sunda pangolins
Africa (Ground)	"First thing that needs to be done is blood needs to be drawn so they can check the blood. Then everyone goes for a sonar scan at the vets. They all get CT scans... That is the standard protocol when a pangolin first comes in, they also give it an injection called stresnil that will keep the [pangolin] knocked out for three days so it can just relax and release all their stress. So normally, the first three days they will tube feed it, they need to put it under anesthesia and then have a tube down its throat because that's the only way you can [artificially] feed the Temminck's in captivity... After the next three days is when they'll start walking the pangolin and that's also when you start looking and diagnosing problems with the pangolin."	• Extensive rehabilitation process that begins with health monitoring, testing, and treatment • Fed through a tube under anesthesia for first 3 days • Typically, does not feed on artificial diets • Must be taken out to forage and eat naturally
Africa (white-bellied, black-bellied)	"Before releasing the pangolin, if we have them, we don't just release them. We have a special weight that they [must] reach before getting them released. So like, they [need] to weigh up to 700 grams before getting them released... If they are 700 grams and they are able to find food for themselves, we'll be left with no option but to take them back to the wild." "So one of the things we do normally. Before the pangolin arrives, sometimes the transport [is] on motorbike, and that causes a huge stress... We first collect it from them, put it in a box, offer water, air, ants for them, and then we place it in a box. If we need to walk, we can leave it in the box and then carry it [to] the forest, open the box and let it come outside by itself and then we start breaking branches for it to get termites."	• Release weight requirement: 700 g • Immediate release if they weigh over 700 g and can forage for themselves • May feed on artificial diets • Reduce stress after being transported • Post-release monitoring is necessary for survival and adaptation • Same process for White-Bellied and Black-Bellied pangolin

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TABLE 2 (Continued)

Continent (pangolin species)	Quote	Key points
	"They're brought by the authorities... Our purpose is to release, [we] do not keep any. They have always been released and after release we've monitored and followed them as far as possible. So the [pups] that we raised, I had a team of [removed], which are the first people who help follow them, monitor them, and sometimes write notes. We've actually managed to get quite a lot of information just from what we call monitoring. So the thing was really, rehab and release."	

Note: Quotes should not be generalized to represent the way pangolin rehabilitation is conducted for each species within each country or continent. Each institution has different rehabilitation processes.

3.4.2 | Indicators of success

All participants had a different definition of success to measure their efforts in pangolin conservation. A participant from Asia explained how success was measured by "mortality rates, how many survive, and how many are released," while a participant from Africa described how their organization does not consider success unless pangolin tags are removed and the individual is thriving in the wild. Several participants indicated that weight is the most effective indicator of recovery:

> In the summer you're always looking for an increase of weight, in the winter you're looking at them to maintain their weight at an optimum level. [Participant from Africa]

According to participants from Asia, the Chinese and Sunda are easier to manage due to their willingness to eat artificial diets. Participants were asked to state their three key aspects of pangolin rehabilitation, with the most common responses including body weight, display of natural behavior, feeding, and bloodwork.

3.4.3 | Progress of rehabilitation

Nearly every participant described how the rehabilitation process has changed over the years. Participants explained how minimal health checkups and hard releases were the norm:

> Recover, check, release it the next day. I don't know it looks fine, release the next day, and we ended up finding out that majority of those pangolins were dead within three to four days after being released because of underlying conditions which we didn't know at that stage. That's how far the rehabilitation of pangolins has come within the last couple of years. [Participant from Africa]

Participants also described a learning curve and how the initial stages of rehabilitation were difficult as information was not readily available. Participants highlighted this shift by explaining that there were previously "no industry standards" but that pangolin rehabilitation is finally reaching a stage where the development of consistent protocols is possible due to trial and error.

3.4.4 | Law enforcement

Nearly all participants explained how they received support from law enforcement and expressed that wildlife rehabilitation was only possible with their support. For example, one participant explained how they only release pangolins in areas that are monitored:

> We release them where we have rangers to monitor the movement in the forest. So they are there to make sure that the animals in the forest, and the forest are all safe. [Participant from Africa]

Participants also expressed how they have the support of local law enforcement to pursue the rescue of pangolins, particularly in Africa. However, three participants from Asia described how government regulations require pangolins to be processed as evidence, a lengthy process that can negatively affect their health and immediate aid.

Naming also helps with law enforcement as a participant from Africa explained that "names are quite vital,

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especially when it comes to the prosecution of the poachers [in] court because it just makes it a lot easier to find that specific file":

> Naming gives us a closer connection with them, it also tells us something. We name them after the person who turned them over, or whoever found them, or the day it was born. Because if you are handling a lot of animals, it's numbers, you don't know any more who is this or what year, so the name will tell us about the origin. And we believe that also communicating with others that animals have a name makes a greater concern. [Participant from Asia]

3.5 | Theme 3—Pangolin well-being

3.5.1 | Stress

All participants had a different definition of stress and welfare based on their observations:

> Stress is the feeling of any emotional or physical tension, which is a response to any external or internal challenges. [Participant from Asia; Indian pangolin]

More often than not, stress was implied to be a physical and mental toll:

> We have seen the ones that just completely, you know, shut down physically and mentally. [Participant from Africa; Ground pangolin]

Participants described how some of the pangolins they worked with presented neurological issues and explained how "seeing a human every day is enough stress." Stereotypic behavior was only mentioned by one participant from each continent:

> It's the same route every time, behavior is the same. They come out, they eat their food, and then they spend the next three or four hours trying to find a way to get out. [Participant from Asia; Chinese pangolin]

The most common sign of stress in a pangolin was identified as curling up, indicating their most common defense mechanism. Urination was identified as another example of stress, particularly when being held or placed in an unfamiliar environment for the first time, along with vocalizations that resembled hissing or puffing when handling was attempted. Several participants explained how pangolins are prone to physiological withdrawal, become nonreactive or overactive, or refuse to feed. Frequent handling can significantly increase stress in pangolins and cause them to exhibit the aforementioned behaviors. The loss of weight was perceived as another strong indicator of stress. Participants from Africa used the phrase "missioning" to describe when pangolins walk in the same direction for extended periods as an indicator of stress. Two participants mentioned a noticeable difference between African and Asian species as they suggested that ground pangolins are more susceptible to stress.

3.5.2 | Health

Most participants discussed illnesses, diseases, tail dragging, and injuries associated with a pangolin's health. Some of the conditions or infections mentioned included pneumonia, biliary, and emaciation. Artificial diets were also proposed to cause health problems:

> We've seen things that we worry about like liver issues and fatty livers... That's because we're feeding them very high rich things... The rich food will lead to health issues, you know, heart conditions, gastrointestinal ulcers, liver pathology, diabetes, those are all things that could be a problem. [Participant from Asia; Chinese pangolin]

Participants also indicated that all pangolin species are quick to deteriorate rapidly, without showing symptoms of disease or injury. Pangolins are capable of surviving and adapting to amputations or injuries, but injuries that include major tail loss or limb loss (e.g., >50% of the tail or above knee/elbow amputations) are generally considered catastrophic as they deter release efforts, lower their quality of life, and limit mobility and natural behaviors.

4 | DISCUSSION

This study provides practitioner-based insights into pangolin rehabilitation across Africa and Asia through both quantitative and qualitative approaches. Our results reveal that both continents share similar challenges, but regional differences emerge in government support and management strategies. The rehabilitation of pangolins in Africa generally emphasizes intensive, hands-on care

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and post-release support, consistent with the direct experiences shared by rehabilitators in the study. In contrast, the rehabilitation of pangolins in Asia prioritizes rapid stabilization and release due to regulations and resource constraints.

4.1 | Challenges

Pangolins are difficult animals to maintain in captivity due to their natural behavior, physiology, and biology (Yang et al., 2007; Zhang et al., 2017). Our results support this view, with most participants stating various challenges with pangolin rehabilitation. Artificial diets, meaning substitutes for meeting the nutritional needs of an animal in captivity and rehabilitation (Wright & Jimerson, 2020; Yang et al., 2007), were a challenge in this study, primarily for the ground pangolin due to their apparent dislike of such diets in a captive environment. Time management is crucial for successful rehabilitation outcomes, a factor that is often overlooked in captive breeding programs due to their primary focus being long-term population management rather than recovery and release. Some pangolin species, such as the white-bellied, black-bellied, and ground, demand a significant portion of a rehabilitator's time due to their foraging behavior. Several stress indicators displayed by pangolins may be linked to captivity and transport conditions associated with space, noises, and smells. Short-term captive situations can negatively impact an animal as their well-being declines (Willette et al., 2023), further reinforcing the idea that transportation poses a challenge for pangolin species. The need for specialized knowledge highlights the gap in scientific evidence and open-access guidelines, emphasizing the importance for further research.

4.2 | Regional and species differences

Despite progress and overall similarities, several substantial differences remain across both continents with pangolin rehabilitation. While funding and resource limitations were reported as common barriers to general wildlife rehabilitation across regions, differences in the nature of impact suggest variation in institutional and ecological contexts shaping rehabilitation practices. In Africa, regulatory and legislative challenges may reflect complexities associated with wildlife trade enforcement and permitting systems, while challenges in Asia related to suitable release habitat, public awareness, and lack of knowledge indicate gaps in ecological availability and capacity for pangolin care. When accounting for pangolin rehabilitation specifically, funding and resources are the primary struggle for practitioners in Africa, restricting staffing, infrastructure, and the ability to provide care. On the other hand, despite their own struggles with funding, practitioners from Asia selected unsuitable habitat and public awareness as their primary barriers, potentially due to the lack of protected release sites and varying levels of community engagement regarding pangolin conservation. Similarly, Rivera et al. (2021) described several limitations regarding confiscated live animals in Asia as political will, policy, funding, capacity, expertise, and attitudes, further reinforcing the findings of this study. Regarding euthanasia, some participants from Southeast Asia highlighted that euthanasia was rarely used due to religion and cultural views (IUCN, 2019; Rivera et al., 2021). These differences highlight the need for specific regional strategies.

Pangolin rehabilitation appears to vary by species, as fossorial and arboreal pangolins have different needs. For example, a rehabilitator walks ground pangolins daily to allow for natural foraging, while Asian pangolins, a mix of fossorial and arboreal, feed on artificial diets and adapt better to enclosures (Wright & Jimerson, 2020). The African arboreal white and black-bellied pangolins are allowed to forage naturally with rehabilitator supervision, but it was not recognized as a necessity for the species, as they also feed on artificial diets. Additionally, artificial diets with high nutritional amounts may pose a potential problem for pangolins in rehabilitation. Organ failure and health issues are reportedly common across pangolin species in rehabilitation, with different examples shared by the participants of this study describing physiological concerns.

Variation between rehabilitation may also be attributed to injuries and admission. African pangolins more commonly appear in rehabilitation due to injuries relating to electrocution, entanglement, dehydration, and fractures. Electrocution and entanglement may be explained by the presence of electric fences and snares across Africa (Pietersen et al., 2014; Stracquadanio et al., 2023). Discussions indicated that poachers may be responsible for pangolin fractures and dehydration during transportation and trade. Puncture wounds were deemed one of the most common injuries in Asian pangolins, linked to reports of feral dog attacks (Home et al., 2017).

4.3 | Animal welfare and stress

Stress indicators presented in pangolins have been identified before, such as defensive behavior, clawing, pacing, infections, and digestive issues (Challender et al., 2011; Hua et al., 2015; Zhang et al., 2017). However, our results

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illustrate other indicators that have not been previously identified in scientific literature, such as inactivity, loss of appetite, weight loss, trembling, rapid breathing, vocalization, and missioning. Positive welfare indicators, which reflect an animal's good physical health, well-being, and ability to express natural behaviors (Boissy et al., 2007), were also explored, with previous literature identifying foraging, climbing, and resting as natural behaviors expressed in captivity (Challender et al., 2011; Swart et al., 1999). Our study reports the aforementioned behaviors as positive welfare indicators, along with curiosity, grooming, and interaction with enrichment items. Enrichment plays a crucial role in rehabilitation as it provides a mental or physical stimulus to animals (Gulas–Wroblewski, 2007) or alters the layout of the environment to promote natural behaviors through environmental enrichment (de Azevedo et al., 2006).

Tail dragging was proposed as an indicator of health, as participants explained that a healthy pangolin, specifically the ground pangolin, typically keeps its tail elevated a few centimeters above the ground, with the lack of tail dragging a positive sign. Health concerns presented in this study aligned with the findings of concerns in captive breeding programs (Hua et al., 2015; Zhang et al., 2017, 2020), proposing a similarity between breeding programs and rehabilitation despite a difference in aim. Overall, a healthy pangolin can reportedly be identified through weight, food consumption, display of natural behavior, and bloodwork.

As captive environments create unique situations and challenges, recognizing the potential impact of exploitation on a pangolin's health and stress through non-conservation activities and entertainment is crucial for their conservation. The stress and noise from captivity, handling, and constant exposure to humans compromise the health and well-being of these creatures. With pangolins being highly susceptible to stress in captive environments, long-term captivity without the proper measures, enrichment, and care can lead to health issues, behavioral problems, and hinder their chances of rehabilitation and release.

4.4 | Limitations

This study was limited by the sample size of participants given the relatively low numbers of people working in pangolin rehabilitation. None of the participants had rehabilitated a giant pangolin before, so our results do not cover this species. Participants indicated that giant pangolins are rare and that their size is a cause of concern for rehabilitation and captivity. Despite these limitations, it is important to note that pangolin rehabilitation has gained momentum but remains relatively new. Further studies are needed to provide information on post-release support, mortality rates, and stress indicators among pangolin species, as study participants reported an increase in admittance over the past few years.

4.5 | Implications and recommendations

The rescue, rehabilitation, and release of pangolins is a contribution to the overall efforts of protecting and restoring these threatened species across Africa and Asia. This research adds to the limited knowledge in scientific literature regarding pangolin rehabilitation by providing information on challenges, strategies, motivations, and indicators of welfare and stress. To better target survivability and rehabilitation outcomes, we recommend greater collaboration between organizations. Countries with guidelines and protocols relating to rehabilitation should share their information with permitted organizations and countries that lack established protocols. Further research that could drastically advance pangolin rehabilitation may be related to pangolin nutrition, particularly developing suitable food sources that can mimic the natural diet of a pangolin to reduce reliance on artificial diets. Comparisons with other burrowing mammals are limited due to taxonomic and behavioral differences, but rehabilitators may look to these practices when facing similar challenges in captivity. Furthermore, given that pangolins can experience significant stress-induced welfare issues in captivity, we suggest that live pangolins are unsuitable for entertainment or fundraising activities.

Improving resource allocation, awareness, and legal support should be seen as a priority by governments, rather than relying solely on the efforts of NGOs and international organizations. Addressing these key issues may ensure that staff are well-trained, facilities are properly equipped, and outreach provides local and global support.

AUTHOR CONTRIBUTIONS

Rodriguez Asael: Conceptualization, Methodology, Investigation, Formal analysis, Data Curation, Writing – Original draft preparation. Christina Hiller: Methodology, Supervision, Writing – Reviewing and Editing. Daniel J. Ingram: Conceptualization, Methodology, Supervision, Writing – Reviewing and Editing.

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CONFLICT OF INTEREST STATEMENT

Daniel J. Ingram is a Field Science Co-Chair of the IUCN SSC Pangolin Specialist Group. Christina Hiller and Rodriguez Asael declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data is not publicly available to maintain confidentiality.

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SUPPORTING INFORMATION

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